Estimating Scaling of Retinal and Cortical Pooling using Metamers

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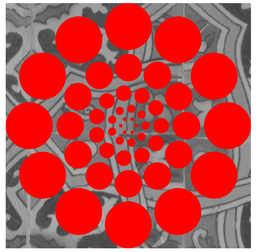
What information are humans insensitive to in the periphery?

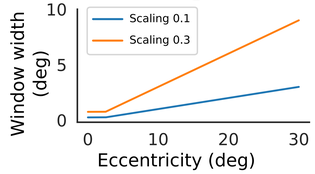
- Develop models of the early visual system.
- Synthesize metamers for these models (c.f., 1, 2).
- Use psychophysics to find largest window size where model metamers become human metamers

Pooling Windows

We model receptive fields as Gaussian pooling windows:



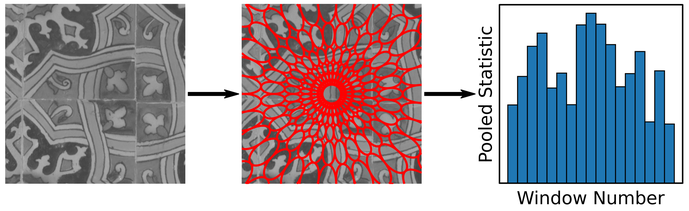
- Uniformly cover image.
- Width grows with eccentricity (2).
- Slope is model's only free parameter: **scaling**.



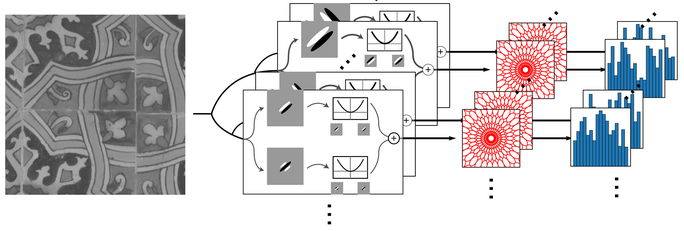
Models

Models pool statistics in Gaussian windows across the image.

Retina model: pools luminance.

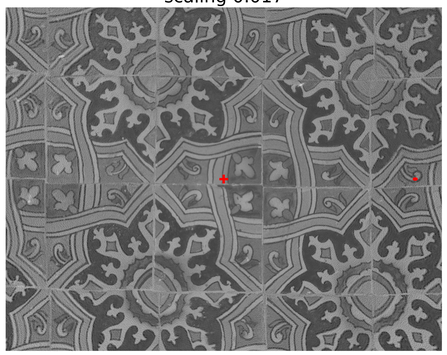


Primary visual cortex model: pools energy at 6 spatial scales, 4 orientations, and luminance.

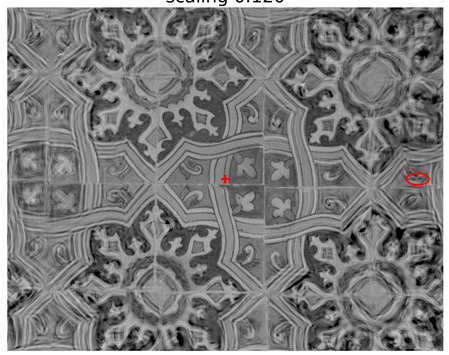


Metamers

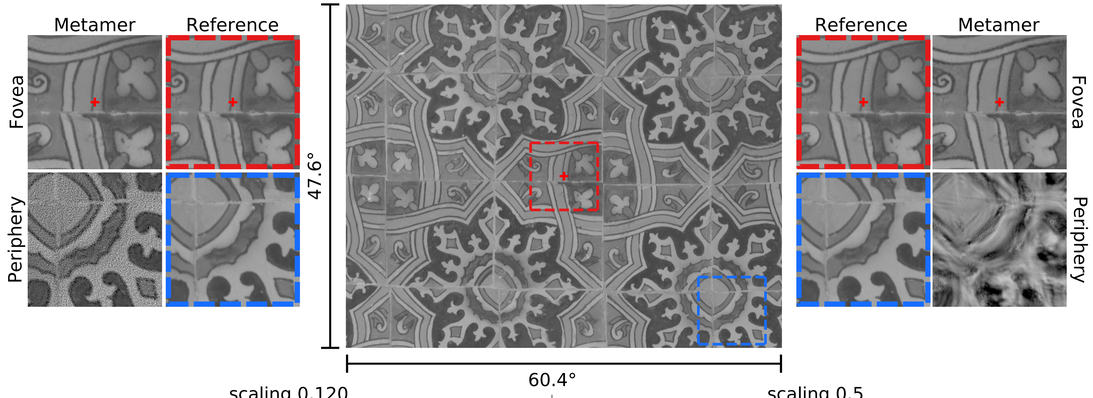
Retina metamers

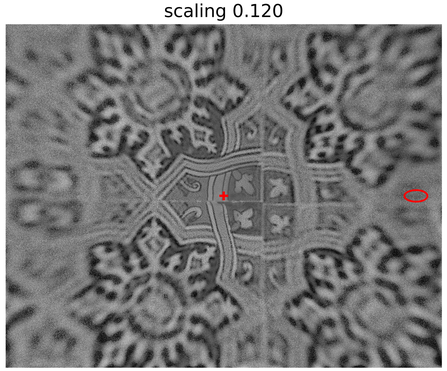


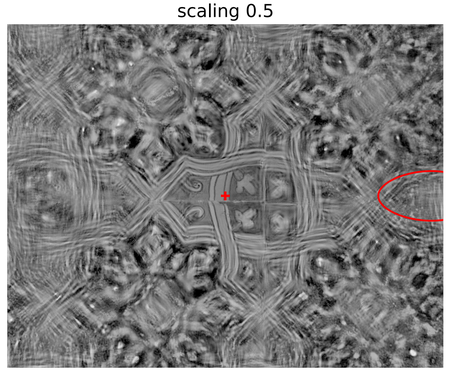
V1 metamers



Reference

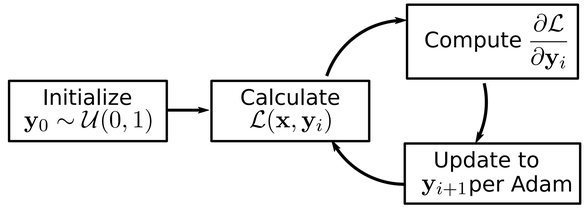




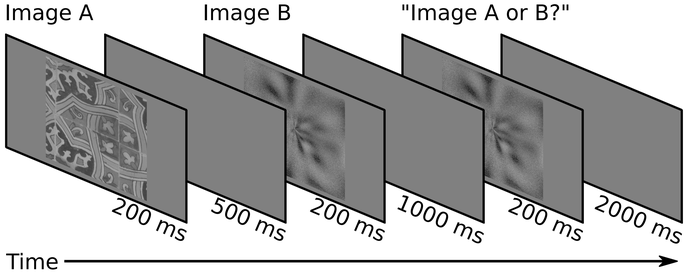


Synthesis

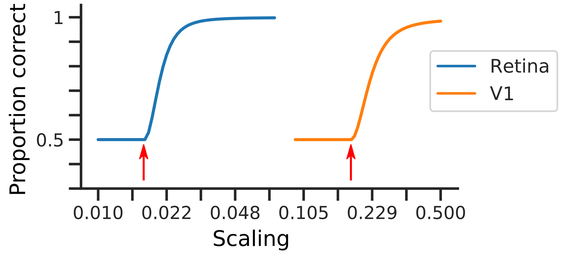
Let $\mathbf{x} \in \mathbb{R}^N$ be the reference image and M be the model, then a model metamer is an image $\mathbf{y} \in \mathbb{R}^N$ which satisfies $\mathcal{L}(\mathbf{x}, \mathbf{y}) = ||M(\mathbf{x}) - M(\mathbf{y})||_2 < \epsilon$, found using Adam, a variant of stochastic gradient descent (3, 4).



Psychophysics (Planned)



Predictions



Link to metamer images on OSF:
https://osf.io/aketq/

1. Balas, B., Nakano, L., & Rosenholtz, R. (2009).
2. Freeman, J., & Simoncelli, E. P. (2011).
3. Kingma, D., & Ba, J. (2014). 4. Reddi, S. J., Kale, S., & Kumar, S. (2018).